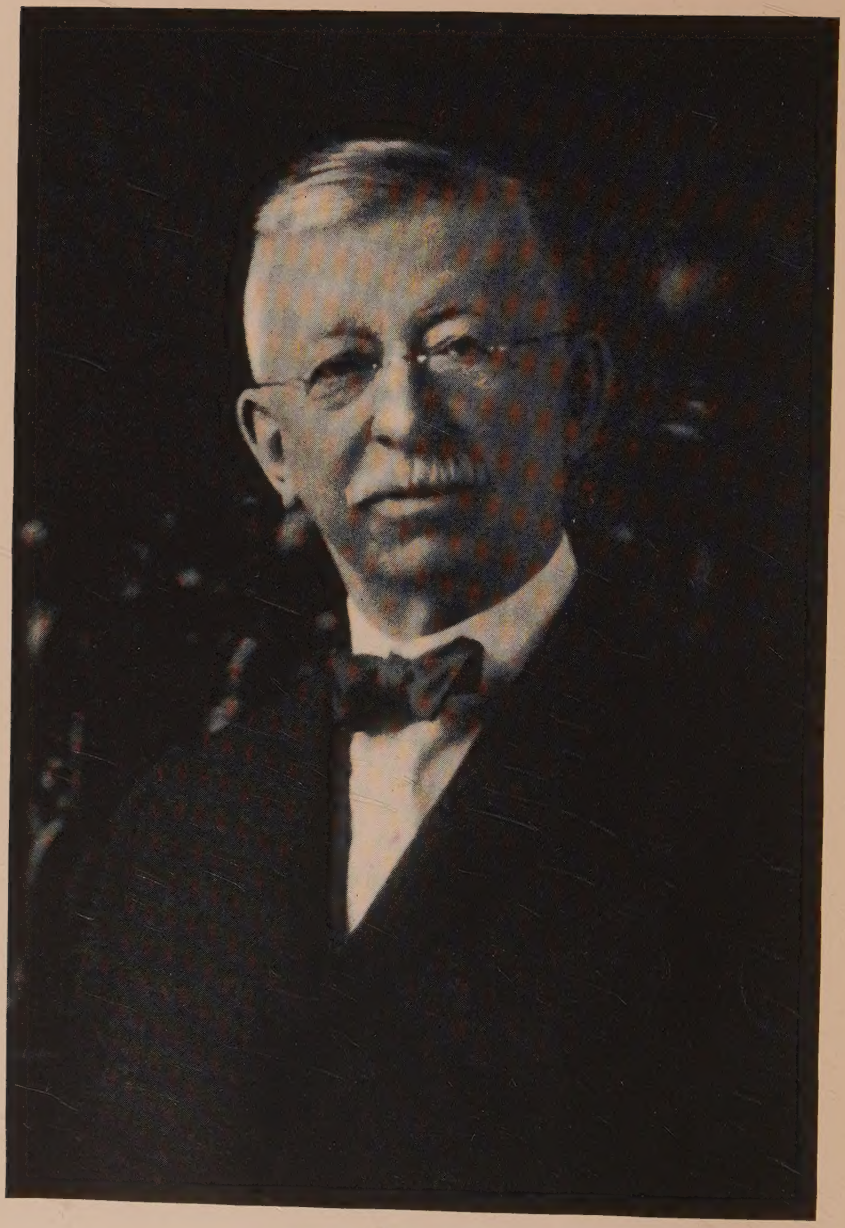
Memorial Service
for
Edgar Fahs Smith

MEMORIAL SERVICE

for

EDGAR FAHS SMITH



Edgar Fahs Smith
1854–1928

Memorial Service
for
Edgar Fahs Smith

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THE PROVOST OF THE UNIVERSITY
OF PENNSYLVANIA PRESIDING

WILLIAM B. IRVINE AUDITORIUM
UNIVERSITY OF PENNSYLVANIA

DECEMBER 4, 1928

BIOGRAPHICAL SUMMARY

Edgar Fahs Smith

Born at York, Pennsylvania, May 23, 1854
Died at Philadelphia, May 3, 1928

Degrees in Course

Bachelor of Science, *Pennsylvania College* (*Gettysburg*), 1874.
Master of Arts, Doctor of Philosophy, *University of Göttingen*, 1876; Reaffirmed, 1926.

Offices of Instruction and Administration

Instructor in Chemistry, *University of Pennsylvania*, 1876–81.
Professor of Chemistry, *Muhlenberg College*, 1881–83.
Professor of Chemistry, *Wittenberg College*, 1883–88.
Professor of Chemistry, *University of Pennsylvania*, 1888–1920.
Emeritus Professor of Chemistry, *University of Pennsylvania*, 1920–28.
Vice-Provost, *University of Pennsylvania*, 1898–1911.
Provost, *University of Pennsylvania*, 1911–20.

Honorary Degrees

Doctor of Science, *University of Pennsylvania*, 1899; *University of Dublin*, 1912; *Yale University*, 1914; *Lafayette College*, 1924; *Wittenberg College*, 1927.
Doctor of Chemistry, *University of Pittsburgh*, 1915.
Doctor of Laws, *University of Wisconsin*, 1904; *University of Pennsylvania*, 1906; *Pennsylvania College*, 1906; *Franklin and Marshall College*, 1909; *Rutgers University*, 1911; *University of Pittsburgh*, 1912; *University of North Carolina*, 1912; *Princeton University*, 1913; *Wittenberg College*, 1914; *Brown University*, 1914; *Allegheny College*, 1915; *Queen's College* (Ontario), 1919; *Temple University*, 1922; *Dickinson College*, 1925.
Doctor of Humanities, *Muhlenberg College*, 1911.
Doctor of Literature, *Swarthmore College*, 1918.
Doctor of Medicine, *University of Pennsylvania*, 1920.

Medals and Decorations

Elliott Cresson Medal, *Franklin Institute* (for distinguished contributions to chemistry), 1914.
Chandler Medal, *Columbia University* (for contributions in the field of historical chemistry), 1922.
Officer of the *Legion of Honor of France* (for distinguished services to chemistry), 1923.
Priestley Medal, *American Chemical Society*, 1926.

Governmental, State and Corporate Offices

Member, Jury of Awards, *Chicago Exposition*, 1893.
Member, *United States Assay Commission*, 1895, 1901–05.
Appointed by President Harding to *Board of Technical Advisers, Disarmament Conference*, 1921. Chairman, *International Committee on Poison Gas and High Explosives.*
Member, *Electoral College for Pennsylvania*, 1917 and 1925 (President of *Electoral College*, 1925).
Member, *Commission for Revision of Constitution of Pennsylvania*, 1919.
Member, *College and University Council of the State of Pennsylvania*, 1911–20.
Member, *State Council of Education*, 1920–22.
Adviser in Chemistry, *Carnegie Institution*, 1902.
Trustee, *Carnegie Foundation*, 1914–20.
Research Associate, *Carnegie Institution*, 1915, 1918–24.
President, *Wistar Institute of Anatomy and Biology*, 1911–22.

Membership in Learned and Academic Societies

Member, *National Academy of Sciences.*
Member, *Society of Chemical Industry.*
Member, *American Philosophical Society* (President, 1902–08).
Member, *American Chemical Society* (President, 1895, 1920–21).
Member, *American Association for the Advancement of Science.*
Member, *History of Science Society* (President, 1928).
Member, *Phi Beta Kappa, Sigma Xi.*
Member, *Phi Kappa Psi Fraternity* (Founder and Editor of "The Shield").
Honorary Member, *Philadelphia College of Pharmacy and Science.*
Honorary Member, *American Electrochemical Society.*
Honorary Member, *American Chemical Society.*
Honorary Member, *Société de Chimie Industrielle* (France).
Honorary Member, *American Institute of Chemistry.*
Honorary Member, *Chemical, Mining, and Metallurgical Society of South Africa.*
Honorary Member, *Chemists' Club* (New York).

Membership in Other Societies

Member, *American Bible Society.*
Member, *Pennsylvania German Society* (President).
Life Member, *Historical Society of Pennsylvania.*
Life Member, *Genealogical Society of Pennsylvania.*
Life Member, *The Print Club.*
Life Member, *Mahogany Tree Club.*
Life Member, *The Fossils.*
Life Member, *Union League.*
Honorary Member, *University Club.*
Honorary Member, *Engineers' Club.*
Honorary Member, *Poor Richard Club.*
33rd Degree and Active Member, Supreme Council, *Ancient Accepted Scottish Rite.*

INVOCATION

The Reverend Richard Montgomery, S.T.D.,
Chaplain of the Day

ADDRESSES

Francis Xavier Dercum, M.D., Ph.D., Sc.D.,
President of the American Philosophical Society

Marston Taylor Bogert, LL.D.,
Professor of Organic Chemistry, Columbia University

Josiah Harmar Penniman, Ph.D., LL.D., Litt.D.,
Provost of the University of Pennsylvania

BENEDICTION

The Chaplain of the Day

INVOCATION

By THE REVEREND RICHARD MONTGOMERY

ALMIGHTY and Eternal God, we meet in the multitude of Thy mercies today to thank Thee for Thy loving-kindness—new every morning and fresh every evening.

Thou leadest us in ways of blessedness; Thy paths are paths of peace. We thank Thee for this our institution, for all that it has meant for the many generations of men who have gone out from it. We thank Thee for the work that they have done in the great world. We thank Thee for the men who are here in various faculties and have taught generation after generation. We bless Thy goodness for the good work which the University is doing today; for the men it is training for leadership in the City, the Commonwealth, the Nation. Men come and men go but Thou hast never left Thyself without a witness.

We thank Thee for him whose memory we honor and love today. We thank Thee for his greatness, but we know he was great because he was good. We recognize that that goodness was Thy gift. It was because he was Thy humble child that he was enabled to do and wanted to do so much for the children of men. We thank Thee that Thou gavest him to us.

We pray that the memory of our beloved Provost, our teacher, may long continue within these walls to be an incentive to the men who teach, to be an inspiration to the men who study, and that out of his life still may come the influence which tends to Thy honor and glory and the good of mankind.

And all we ask is the forgiveness of our sins, as in the name and for the sake of Jesus Christ our Lord. Amen.

ADDRESS

By DR. FRANCIS XAVIER DERCUM

WHEN Dr. Penniman requested me to take part in these exercises, commemorative of Dr. Edgar Fahs Smith, he suggested that I make my remarks, in part at least, personal. This, because of the long standing friendship which had existed between Dr. Smith and myself and because of the affection which I had entertained for him for so many years, I am very happy to do; the more so as this was also the expressed wish of Mrs. Smith.

My first acquaintance with Dr. Edgar Fahs Smith dates back to 1877. At that time a group of recent graduates of the medical department of the University, including myself, formed an association of quiz masters. This association succeeded an older and long established quiz association which had been known as the Philadelphia Medical Institute. The latter was an organization in which quite a number of ambitious young men who subsequently became teachers in the University Medical School had been quiz masters. For some years this association, because of the increasing demands made upon the time of some of its members by the University and because of the increasing demands of hospital and private practice, became less and less active, and the organization finally dissolved. It had been a very successful organization, had been chartered by the legislature of Pennsylvania and had the right to teach medicine but not to grant degrees. After the dissolution of this now older group, the charter remained in the hands of Dr. Charles T. Hunter, the assistant in chief in those days to Professor D. Hayes Agnew. Dr. Hunter very graciously transferred the charter to our newly formed organization and also rented to us the house which this older group had occupied. This house was a small brick build-

ing, two stories in height, situated on Woodland Avenue, just opposite the University. The first floor contained a small anteroom and immediately back of this a tiny one-half amphitheatre. On the second floor there was a relatively large room which also answered admirably the purpose of a quiz room. I may remark here, in passing, that at this period, comparatively little demand was made upon the medical student's time; that is, when contrasted with the present day. The student was expected to attend the various didactic and clinical lectures, and also to take part in the laboratories that were being gradually introduced. This, however, left abundant time for attendance upon quiz classes, and attendance upon such classes was actively encouraged by various members of the faculty. Coaching, or quizzing, as we termed it, was deemed in those days, and, I think justly so, to be a not unimportant part of the student's training. Indeed, many students leaned upon it heavily as a much needed auxiliary part of their instruction.

At this period of the University's history, there was no connection whatever between the College Departments and the Medical School. The latter was practically an independent institution in which each professor sold the tickets to his individual course. Nominally only was it under the government of the Board of Trustees of the University. Although the Medical School and the College Departments were so distinct and separate, it did not take the younger group about the Medical School long to discover Dr. Edgar Fahs Smith. We drifted together almost spontaneously and soon felt as though we had known each other always. It was quite a matter of course, therefore, when we formed our quiz organization, that we should ask him to join us. He willingly accepted and it was arranged that he quiz on chemistry. He was at that time instructor in chemistry in the laboratory of Professor Genth. In those, now far-off days, the students on matriculating in the Medical School were not required to have a preliminary knowledge of chemistry, and therefore the teaching of chemistry in the Medical School was devoted largely to inorganic chemistry to which a very little organic

chemistry was added; the latter, indeed, was called "medical" chemistry and embraced little else than the chemistry of the secretions and of the blood and was of a character that today would be considered merely elementary. To myself was assigned the subject of materia medica and therapeutics and, in addition, that of organic chemistry. Very justly one of our colleagues frankly questioned my fitness for the latter branch, and it was Dr. Smith who became my enthusiastic advocate and defender. I need not add that in our young and boyish group, sincere friendships were formed, not only among the members of our quiz association, but also between quiz masters and students; some of these endured a lifetime. This was especially true, I need hardly say, in the case of Dr. Smith. Our organization, which embraced among others my very dear and much lamented friend and classmate, Dr. John H. Musser, the elder, was very successful; but very soon we individually became more and more busy in the rapidly expanding laboratory teaching and hospital instruction of the University, so that we in turn were obliged to hand over our quizzing to other and still more recent graduates. About this time too, in 1881, Dr. Smith was called to the chair of chemistry in Muhlenberg College. I remember to this day how great was our sorrow when he left us, but how glad we felt, on the other hand, at his promotion to a full professorship. He remained, as is well known, at Muhlenberg two years when he was called to Wittenberg College, Ohio, where he remained five years. Our friendship during all of this time remained unbroken and when he returned after an absence of these seven years and became professor at the University of Pennsylvania, our pleasure was very great indeed. Dr. Smith had in the early and formative period of our lives entered very closely and sympathetically into our several projects and ambitions, and when we met often took an active part in our scientific discussions, discussions usually impromptu, but none the less to us extremely interesting and important. In short, he had established himself in our warm regard and affection, and when he returned to Philadelphia, although we had all given up quizzing, we felt that he had in a sense

returned to us, and, furthermore, that the University trustees had acted not only wisely but in accordance with the sentiment of the younger groups of teachers of the various departments of the University. Dr. Edgar Fahs Smith had begun original scientific work as early as 1876 when but twenty-two years of age, and scientific contribution followed scientific contribution during the five years that he was instructor of chemistry at the University of Pennsylvania and during the seven years that he was away at Muhlenberg and Wittenberg. During this period some thirty original contributions had come from his hand, and he had fully earned the call to fill the chair of chemistry at the University. This came to him in 1888 when he was but thirty-four years of age. He had proven himself a worthy successor of the distinguished Professor Genth.

His return to Philadelphia was not only welcomed by his old companions of the quiz association, but by many others, among whom was Dr. John Marshall. The latter, also a prominent chemist and like Dr. Smith a student of Göttingen and for many years professor and dean in the Medical School of the University, was a close personal friend of Dr. Smith, and many pleasant occasions, social in character, featured the years that were to follow. Although I myself was called from the University in 1892 to fill a newly created chair in the Jefferson Medical College where new friendships and new associations awaited me, I never lost touch with the group of my early days, and especially was this true of my relations with Dr. Smith.

After his return to the University in 1888, his activity in scientific work was as before unremitting. In addition he was made Vice-Provost in 1898 and Provost in 1911, and upon each occasion this recognition by the University was an occasion for felicitation; but despite his labors as teacher and Provost, research after research followed. He was the author all in all of some two hundred and fifty publications. One hundred and sixty-seven of these were distinct and strictly scientific contributions to chemical knowledge. More than a dozen others were scientific books. In addition, he wrote seven books on the his-

tory of chemistry and no less than thirty-two brochures dealing with the lives of chemists and other scientists; and on cognate subjects. Beside all this, a very large number of investigations—some ninety in number—were carried on at his suggestion and under his supervision and in his laboratory; and all of these were published.

His industry was truly amazing; but, though his life was a very busy one, he always had time for something more, especially if this was interesting or in his judgment important. Such an occasion was the celebration of the centenary of the birth of Pasteur. Pasteur was a chemist. This was enough to engage the enthusiasm of Dr. Smith. Pasteur, whose investigations were destined to prove of inestimable value to mankind, began his epoch-making discoveries by studying the relations which some of the lower forms of life bear to the chemical changes occurring in fermentation and putrefaction. His discoveries led rapidly to the unravelling by himself and by his followers in his and other countries, of the relations of bacteria to many of the diseases to which man and animals are subject. They also led to the study of toxins and the applications of antitoxins, sera and serobacterins in the treatment of disease; and to related matters. They led to the development of the great fields of bacteriology and of immunology, and, may I add, they led directly to the priceless application by Lister of Pasteur's discoveries and to the development of antiseptic surgery. It is needless to say that when the matter of celebrating the centenary of Pasteur's birth was brought to his attention, Dr. Smith at once took an active and enthusiastic part. A general committee was formed under the Presidency of Dr. William Duffield Robinson who had proposed the celebration. At the same time a very large National Committee, consisting of physicians, chemists, biologists and other scientists representing various parts of our country, was added. On December 27, 1922, the date of the one hundredth anniversary of the birth of Pasteur, a meeting was held at the Academy of Music in Philadelphia at which five addresses were delivered by persons of great distinc-

tion and broadcast widely by radio. At this meeting, Dr. Smith presided with his usual dignity and simplicity, introducing each of the speakers with a few appropriate remarks. In the evening five additional addresses were delivered at the Bellevue-Stratford Hotel, likewise by persons of world-wide distinction; one of the latter was a special delegate representing officially the French Government, Dr. Étienne Burnet, himself a distinguished pupil of Pasteur. Dr. Smith by his active, stimulating interest and his many suggestions contributed largely to the success of this notable occasion. His own achievements, many of them remarkable, had been in inorganic chemistry, especially in the field of electrolysis, and, great scientist that he was, he appreciated to the full extent the great pathways which Pasteur had blazed in that other field of chemistry, the organic world. At all of the many meetings which our local committee held, he emphasized the fact that Pasteur had been primarily and essentially a chemist, and he derived especial satisfaction and pleasure from this fact.

Dr. Smith became a member of the American Philosophical Society in 1887. He was but thirty-three years of age when this distinction was conferred upon him. Subsequently he contributed a number of scientific papers and observations to the *Proceedings*. In January, 1903, he was chosen President and served until the close of the year 1907. During his presidency an unusual number of papers was presented at the stated meetings, while the annual meetings were likewise notable for the number of scientific and other learned contributions. It was during his presidency, too, in 1906, that the celebration of the bicentenary of the birth of Benjamin Franklin was held. He fully appreciated the historic importance of this occasion and was very active in promoting its success. The celebration was attended by distinguished visitors from both at home and abroad and the proceedings were published in a special commemorative volume.

Dr. Smith was a member of a very large number of other scientific bodies and of other learned organizations and insti-

tutions. These, about thirty-odd, are too numerous to detail here; special mention, however, may be made of the American Chemical Society of which he was three times President, of the National Academy of Sciences and of the Society of Chemical Industry. He was also an Officer of the Legion of Honor of France. In 1914 he was awarded the Elliott Cresson Medal of the Franklin Institute for distinguished contributions to chemistry; in 1923 he was awarded the Chandler Medal of Columbia University for his writings in the field of historical chemistry; and in 1926 he was awarded the Priestley Medal of the American Chemical Society.

Dr. Smith's tireless activity in scientific research brought him abundant recognition in other ways. Upon twenty-three separate occasions, universities and colleges in this and other countries conferred upon him honorary degrees; five times doctor of science, fourteen times doctor of laws, once doctor of chemistry, once doctor of the humanities, once doctor of letters and once doctor of medicine. At the anniversary of the fiftieth year of his graduation, the University of Göttingen granted him afresh a diploma of doctor of philosophy. This list of honors is truly an amazing one; one which I can safely say is not and will not be often duplicated.

What manner of man was he who was so honored? What manner of man was he who had achieved such distinction? No honor or preferment was ever sought by him; none ever spoiled him; none ever made a change in his attitude to those about him. He seemed indeed not to be conscious of the constantly increasing esteem and appreciation with which he was regarded. Nothing drew his attention from the work before him, from the tasks and duties imposed by each recurring day. He never talked about himself nor of the great things that he was doing. Entirely without recognition of self or of his own importance or of the great rôle that he was playing in the advance of science or in the great progress of the University under his administration, he was utterly selfless, and, added to this, his sympathies were broad and human. Sometimes when I met him, he would

mention some interesting research taking place in his laboratory; upon one of the later occasions, it was germanium of which he spoke, and which he thought might prove to be of special value in medicine. His interest in chemistry was at all times unabated. At a meeting of the Philadelphia Medical Club, a year or two ago, he spoke at length and in an entirely impromptu manner upon the importance of chemistry, pointing out among other things its great practical application to medicine. His mind, indeed, had an exceedingly practical turn. The recent theories of the physics and of the structure of the atom and the relation of these theories to chemistry interested him, I think, less than the concrete results of new discoveries and the practical application of these discoveries.

Sometimes, when I met him, he would talk to me, not about chemistry, but about some poor and struggling student working his way through college, or, again, of some other student for whom a widowed mother was making great sacrifices in order that her son might secure an education. He was thoroughly democratic in educational matters and believed in opportunity for all who desired and were fitted for higher training. The student body appealed to him not only individually but as a whole, and though the University of Pennsylvania was not his alma mater, he was sincerely and deeply devoted to her interests. His personal and amazing generosity to the University, which came to light only indirectly, speaks volumes as to the truth of this statement. Further, his concern was not limited to any one department of the University, but embraced them all. He looked upon the University as a whole with but one aim and purpose.

Joined to these qualities of mind and heart, there were others equally admirable, not to say lovable and human. He retained a sincere affection for the friends of his earlier years. There was a small group of these, some eight or nine in number, most of whom had studied abroad. Many times this group met on an occasional Saturday night at the home of Dr. John Marshall, at other times and more frequently in later years at my own.

Here, at table, were told stories of student life, at home and abroad; reminiscences of all kinds cropped to the surface; occasionally a student song rose to the lips of this or that member of the group and now and then Dr. Smith would call to mind the words of a student song learned many years ago at Göttingen. The evening was always one of genuine relaxation and enjoyment and no one was in a hurry to go home. Dr. Smith to me was always young; always a member of what I had years before called the "younger group." He was never old, and his lovable personality was always the same.

Not only was Dr. Smith beloved by his many friends, but also by the students. Fortunately for us and for those who come after us, his form and features are preserved in a statue on the grounds of the University, while in the American Philosophical Society hangs his portrait where it occupies a place amidst a galaxy of great men. In the Harrison Laboratory of Chemistry, there is a room which he occupied as a study and office. In this room are stored a large number of books, a library in fact of more than four thousand volumes, which were the personal possession of Dr. Smith and which he especially prized. They deal, of course, with the subject of his life work, chemistry, and particularly with books dealing with the history of chemistry. There is also present a large collection of papers bearing upon the lives of chemists and innumerable letters of chemists of great distinction. This collection, the great French chemist Bertrand, at the time of his visit to this country some years ago, declared to be the finest collection in existence. In addition, there are also letters of ten signers of the Declaration of Independence, all of whom were graduates of the University of Pennsylvania. Besides there are many beautiful engravings and portraits, between eight and nine hundred, of early chemists, men who had been pioneers in Dr. Smith's chosen field, and who had achieved especial prominence. Special mention may perhaps be made of the portraits of Mendeljeff, Berzelius, Pasteur, Farraday and Wöhler; also books and apparatus at one time belonging to Priestley; especially the apparatus which

Priestley used in his discovery of oxygen; also the lock of Priestley's home in England. Among the many interesting features in this room, also, is a shelf of books which has an altogether peculiar value; it consists of the textbooks which Dr. Smith used while a student at the University of Göttingen. On the same shelf, too, one finds an interesting little volume in which are bound the serial numbers of two sets of journals. The first set is made up of the numbers of a journal bearing the title of "Our Effort." It was clearly a school-boy production, the articles of which were largely contributed by Dr. Smith. The typesetting and printing were all done by him. It appears that "Our Effort" ran for about a year. It was succeeded by another journal, which bears the title of "The Poulterer," and this likewise is an interesting evidence of his rapidly growing personality. The length of life of "The Poulterer" was about that of "Our Effort." Dr. Smith was but fourteen and fifteen years of age at the time of these ambitious productions in writing, printing, and publishing and they strongly call to mind the early history of Benjamin Franklin. In the love and unselfish devotion to science, which he developed in early life, and in the wealth of the contributions of his maturer years, he may truly be said to have been a worthy follower of the Founder of our University and of the American Philosophical Society. It is gratifying to know that this room is to be for all time preserved in its entirety, and without change, just as it was while Dr. Smith was living. The walls and books speak of him; the very atmosphere is pervaded by his personality. It is difficult to realize that he is no longer there. It is, indeed, fitting that this room should be as a shrine perpetuating his memory.

When we reflect upon his very unusual history, we cannot help but wonder, how was it possible for this man to accomplish so much, to make so many investigations, to write so many books, to play so great a rôle in the history of science and of our University? How was it that he was able to devote every conscious hour unremittingly and unceasingly to work? The answer lies in the fact that he had been blessed with a helpmeet

who relieved him of every possible worldly care, and this continued throughout his long life and embraced all of those intimate details which only good and devoted women know. Early in his career, too, he could find time for original research only in the evenings, as every hour of the day was filled by teaching and by college duties. For a period of several years, this faithful helpmeet was his constant companion during these evenings of work in the laboratory which usually extended late into the night. That she was a source of encouragement to him and that she shared his enthusiasm, we may well believe. But for the singleness of purpose, the self-effacing, whole-hearted devotion which inspired her, Margie A. Gruel Smith, his great career would not have been possible; for this man so great in many ways had no thought of the ordinary affairs of life or of the homely details of everyday existence. Truly, he was not like other men. To turn the scientific discoveries he was making, for instance, to his own advantage seems never to have occurred to him. Time and again he might have secured patents for this or that discovery, patents from which, as in the case of his researches on tungsten, he might have realized a fortune; but truth alone appealed to him, nature's truth, scientific, abstract, ideal truth. His life, so rich and full, was expressive of a simple dignity in which worldly matters had no place. This man so sincere and so lovable, is no longer with us, but when we call him to mind our thoughts of him are like strains of sweet music, and we again enter the beautiful world in which he lived. He is gone, it is true, but he will ever be with us as a beautiful memory.

ADDRESS

By DR. MARSTON TAYLOR BOGERT

IN turning the pages of that great final Ledger wherein are recorded our life's endeavors and accomplishments, I find a noteworthy account which reads thus:

American Chemistry, Debtor

To Edgar Fahs Smith, of Philadelphia, Pa.

For services rendered from September, 1876, to May 3, 1928, 52 years, as follows:

Item 1.—As educator, who with rare charm and power, portrayed to tens of thousands of his fellow Americans, both students and others, the multifarious and marvelous ways in which chemistry contributes to the advancement of civilization and to the prosperity and happiness of the individual, how its work is carried on, the splendid opportunities it offers for service to mankind, and what it may reasonably expect to accomplish in the very near future; with the result that the public were given a better appreciation and a clearer understanding of its importance to their well-being, and that the many young people thereby induced to make chemistry their life's business, received a training and an inspiration which made them more useful and more patriotic citizens of higher and nobler ideals.

Item 2.—As guide, counselor and loyal friend to all who were so fortunate as to know him, and especially as older brother to all younger chemists. No one who approached him ever failed to receive a cordial welcome, a patient and sympathetic hearing of his problem, whether scientific or personal, and sound advice as to the proper line of action. In the laboratories, he labored not merely shoulder to shoulder, but heart to heart with his staff and students. Their sorrows and unhappiness brought grief to him. In their triumphs and happiness he rejoiced. Into their characters he built his own, and that memory will

remain to these generations of students as a refining and ennobling influence which will continue until they too will have completed "life's great adventure." The world's tributes of honors and decorations are but as dross compared to these priceless riches of human lives. The alumni will read with pride the long list of his honors, but these honors will not cause the same tug at the heartstrings as the recollection of the touch of his hand, the sound of his friendly voice, or the welcoming smile upon his well-beloved face.

Item 3.—As an example to all of the beauty and dignity of a life of simplicity, self-forgetfulness, and devotion to all that is noblest and best, and the fact that a chemist is also an American citizen and as such owes to his country the discharge of those civic and patriotic duties for which his talents and training especially fit him or which are properly expected of all good citizens. There is great need for chemists in public life, but few are found willing to make the sacrifices which such service entails.

As member of the U. S. Assay Commissions of 1895 and 1901–5; as member of the Electoral College for Pennsylvania in 1917, and as President of the same in 1925; as member of the Commission for the Revision of the Constitution of Pennsylvania in 1919; of the Committee for Public Safety, in 1919; of the College and University Council of the State of Pennsylvania from 1911 to 1920; of the State Council of Education from 1920 to 1922; and as member of the Board of Technical Advisers for the United States, and Chairman of the International Committee on Poison Gases and High Explosives, at the Disarmament Conference of 1921; he gave ungrudgingly and unstintedly of his time, strength, and ability, to the solution of problems of importance to his state and his country, both of which are the poorer for his passing.

Item 4.—As author of books on theoretical and applied chemistry, some of which have gone through many editions and have been translated into French, German, Italian, Russian and Chinese. These books are *Electro-analysis*, *Chemical Experi-*

ments for Students in General Chemistry (with H. F. Keller), *Chemical Analysis of the Urine*, *Elements of Chemistry in Lecture Form*, *Elements of Electrochemistry*, *Theories of Chemistry*, *Chemical Experiments*, *Shorter Course*, and *Atomic Weights*.

Of these, the books on the elements of electrochemistry and on electro-analysis were particularly valuable in directing attention and stimulating research in a field which prior to their appearance had been largely neglected.

Item 5.—As translator of books in other languages, thus making them available to English-speaking chemists. Such are Classen's *Quantitative Analysis*, von Richter's *Inorganic Chemistry* and *Organic Chemistry*, Oettel's *Introduction to Electrochemistry* and *Practical Exercises in Electrochemistry*.

Item 6.—As biographer of American chemists and historian of American chemistry, a field in which he was not merely the recognized leader but was actually in a class by himself.

Item 7.—As a conspicuous illustration of the value to a chemist of an education also in literature and the liberal arts, so as to enable him to express in clear, convincing, and attractive style those ideas or opinions which he is seeking to convey to his reader.

Item 8.—As a member of numerous scientific organizations, as may be gathered from the following record: Honorary Member of the American Chemical Society and its President in 1895, 1920 and 1921; President of the American Philosophical Society, 1902–8, and of the History of Science Society in 1928; Honorary Member of the American Electrochemical Society, of the Institute of Chemistry, of the Chemists' Club of New York, of the Engineers' Club of Philadelphia, of the Philadelphia College of Pharmacy and Science, of the Société de chimie industrielle of France, and of the Chemical, Mining and Metallurgical Society of South Africa; member of the National Academy of Sciences, of the Society of Chemical Industry, and of the honor fraternities of Phi Beta Kappa and Sigma Xi; adviser in Chemistry for the Carnegie Institution, 1902, and one of its Research Associates in 1915 and 1918–24; Trustee

of the Carnegie Foundation, 1914–20; member Jury of Awards Chicago Exposition, 1893; and President of the Wistar Institute from 1911 to 1922.

Item 9.—As original investigator in the fields of organic, inorganic, analytical and electrochemistry, as evidenced by over 160 scientific papers and the supervision of 92 Doctor of Philosophy dissertations.

Received in part payment of the above account:

The approbation, esteem, and affection of all who knew him, as well as the highest honors from his fellow chemists, from his alma mater, from other educational and scientific organizations, and from cities, states, and nations.

Balance still due:

A permanent place in the Valhalla of Chemistry, the cherishing of his memory by all, and the carrying forward of that flaming torch of devotion to the service of mankind which he himself bore so nobly and which he passed to us as his own strength ebbed away.

To convince ourselves that this bill is correct in all of its particulars and specifications, let us examine somewhat more closely a few of its items.

Dr. Smith's chemical career may be said to fall roughly into the following periods, arranging them in chronological sequence and according to the fields of major activity at the time:

I. Organic Chemistry
II. Inorganic, Analytical, and Electrochemistry
III. Historical Chemistry

I. ORGANIC CHEMISTRY

At the University of Göttingen, Edgar F. Smith pursued his studies in chemistry under the world-famous Friedrich Wöhler, and received the degrees of A.M. and Ph.D. from that institution in 1876. As a signal honor to Dr. Smith, these degrees were renewed by this University in 1926 for his "fifty years of science as teacher and investigator."

Upon his return to the United States, in the fall of 1876, he was appointed Assistant in Analytical Chemistry to Professor F. A. Genth, in the Towne Scientific School of the University of Pennsylvania, leaving in 1881 to take the Asa Packer Professorship of Chemistry in Muhlenberg College, Allentown, Pennsylvania, where he remained for two years and then moved to Wittenberg College, Springfield, Ohio, as Professor of Chemistry, resigning his position in 1888 to accept the chair of Analytical Chemistry at the University of Pennsylvania made vacant by the resignation of Professor Genth. In 1892, following the retirement of Professor Samuel P. Sadtler, the man who really inspired him to devote his life to science, Dr. Smith was designated as Head of the Department of Chemistry, to which was added that of Vice-Provost, when Dr. George S. Fullerton withdrew in 1898. The title of his chair was changed in 1907 to the Blanchard Professorship of Chemistry. His election as the thirteenth Provost of the University occurred in 1911, following the resignation of Dr. Charles C. Harrison, and he carried the combined burdens of Provost and Professor of Chemistry until his retirement in 1920 as an emeritus Professor of Chemistry.

At the University of Göttingen his research work for the doctorate had consisted in a study of "the trisubstituted benzol compounds and the action of chlorine upon benzyl trichloride," in the course of which he investigated the effect of exhaustive chlorination of benzotrichloride, assisted by intermittent exposure to direct sunlight, and isolated a new chloride of carbon, to which he assigned the formula $C_{21}Cl_{26}$ (m.p. 152°–153°), which was reduced by zinc and sulphuric acid to another new chloride, $C_{22}HCl_{25}$ (m.p. 102°), or by sodium amalgam to various unidentified products (Edgar F. Smith, *Inaug. Dissertation*, University of Göttingen, 1876; *Jahresber.*, *1877*, 421; *Proc. Am. Philos. Soc.*, *17*, 29 [May 4, 1877]).

Heated with aniline at 180°, it yielded a new crystalline and very easily soluble base, the constitution of which was not determined (Smith, *Am. Chem. J.*, *1*, 150 [1879]).

After standing for twelve years, the m.p. of this $C_{21}Cl_{26}$ com-

pound fell to 101°, although its percentage of carbon and hydrogen remained approximately the same. (Smith and Keller, *J. Franklin Inst.*, *127*, 311 [1889]).

Salicylic acid was one of the organic compounds under investigation in the Göttingen laboratory during Dr. Smith's student days there, so that it is not surprising that we find him directing his own attention next to this interesting acid and its isomers, and in 1877 (*Proc. Am. Philos. Soc.*, *17*, 68 [1877]) he published a paper "On a dichlorsalicylic acid and on monochlorsalicylic acid," in which he observed the formation of a dichloro (m.p. 212°–214°) and a monochloro (m.p. 172°) salicylic acid when chlorine was passed into an acetic acid solution of salicylic acid. Salts and other derivatives were prepared of both of these chloro acids (Smith, *Proc. Am. Philos. Soc.*, *17*, 68 [June 15, 1877]; Smith and Macchall, *Ber*, *11*, 1225 [1878]).

This work was an attempt to duplicate the results obtained by Rogers (*Inaug. Diss.*, University of Göttingen, 1875), who, by similar treatment of salicylic acid, secured a dichloro acid of m.p. 224°.

Smith's acids were proven subsequently, by other investigators, to be the 3, 5-dichloro and 5-monochloro derivatives. In association with Hoskinson (*Proc. Am. Philos. Soc.*, *24*, 432 [Nov. 18, 1887]), he showed that this same 5-chlorosalicylic acid (m.p. 172°), when treated with bromine in alcoholic solution, gave a bromochlorosalicylic acid (m.p. 229°), from which various salts and esters were prepared. He found, further, that the corresponding bromosalicylic acid, when iodinated in alcoholic solution by the method of Weselsky, yielded an iodobromosalicylic acid (m.p. 208°–209°), from which he also prepared certain salts and the methyl ester.

With Knerr (*Am. Chem. J.*, *8*, 95 [1886]), he proved that 5-chlorosalicylic acid could be converted into the iodochlorosalicylic acid by the action of iodine in alcoholic solution, in the presence of oxide of mercury; but that, in the absence of the latter the product was the iodochlorobenzoic acid. Many salts of the iodochlorosalicylic acid were described.

As early as 1880 (*Am. Chem. J.*, *2*, 338 [1880]) he effected a synthesis of salicylic acid from benzoic acid by heating copper benzoate and water together in a sealed tube for three hours at 180°, or benzoic acid, water, and an ammoniacal solution of cupric oxide at 220°; although the yields in both cases were very low.

The delicacy of the salicylic acid reaction for ferric iron was tested by him (*Proc. Am. Philos. Soc.*, *18*, 214 [Mar. 21, 1879]) by adding an alcoholic solution of the acid to an aqueous one of ferric chloride and it was found that 1/32,000th of a mg. of iron could be detected in this way. With monochloro (m.p. 172°), or dibromosalicylic acid (m.p. 218°), the test was less delicate.

Smith and Knerr (*Loc. cit.*) discovered that when nitrous anhydride was passed into an ethereal solution of oil of wintergreen, the 3- and 5-nitro derivatives of methyl salicylate were produced and could be separated easily by their different solubility in ether.

It was known already that the action of fuming nitric acid upon 5-chlorosalicylic acid gave a nitrochlorosalicylic acid (m.p. 162°–163°) and 4-chloro-2, 6-dinitrophenol (m.p. 78°–80°) when Smith and Miss Peirce (*Proc. Am. Philos. Soc.*, *17*, 706 [June 21, 1878]; *Am. Chem. J.*, *1*, 176 [1879]) showed that there was formed also in this reaction another chlorodinitrophenol, subsequently proven by others to be the 6-chloro-2, 4-dinitro-isomer (m.p. 110°–111°). Smith noted that the 4-chloro-2, 6-dinitrophenol, which differs from picric acid only in having a chlorine in place of one of the nitro groups of the latter, combined directly with aniline and various other bases to beautiful crystalline compounds apparently in the same way and of the same character as the analogous picrates. Ten years later (Smith, *J. Franklin Inst.*, *128*, 156 [1889]) he extended this reaction to other aromatic bases and to anthracene, and also uncovered the interesting fact that dichloronitrophenol does not form similar compounds with aromatic bases or with anthracene, from which he drew the conclusion that at least two nitro groups must be present on the nucleus of the phenol to obtain such products.

Having studied salicylic acid and its derivatives, it was quite natural that he should turn his thoughts also to the isomeric *m*- and *p*-hydroxy benzoic acids, and in 1888 and 1889 (*Proc. Am. Philos. Soc.*, *25*, 165 [Sept. 7, 1888]; *J. Franklin Inst.*, *128*, 488 [1889]) he reported the results of his investigations of the actions of the gases from arsenic trioxide and nitric acid upon an ether solution of the ethyl ester of each of these two acids. In the case of the *meta* acid the products were the 4-nitro ester (m.p. of the free acid, 230°), a trinitro derivative and unidentified substances. From the *para*-hydroxy ester, he obtained a nitro ester carrying its nitro group *ortho* to the hydroxyl, and from this he prepared the free acid (m.p. 184°–185°), certain salts and the amide.

After 1889, his interest in the organic field seems to have waned, as he became more and more engrossed in the problems of inorganic, analytical, and electrochemistry, and it was only infrequently thereafter that he returned to it, to direct an occasional dissertation of some graduate student wishing to pursue his studies in that direction, like that of Seal (1895) on "The action of acid amides upon benzoin," or of Ryan (1897) on "Derivatives of pyroracemic acid"; or a brief research, as that with Hanna (Hanna and Smith, *J. Am. Chem. Soc.*, *21*, 381 [1899]), entitled, "Observations on derivatives of aconitic acid." In pursuing his researches in the electrochemical field, organic compounds were occasionally selected for the experiments, as in the application of the electric current to accomplish the oxidation of succinic acid (Clarke and Smith, *J. Am. Chem. Soc.*, *21*, 967 [1899]), or of toluene (Merzbacher and Smith, *Ibid.*, *22*, 723 [1900]), its action upon benzoin and benzil (J. H. James, Dissertation, 1899), "The influence of substituents on the electric conductivity of benzoic acid" (A. Tingle, Dissertation, 1899) and "An electrolytic study of pyroracemic acid (G. W. Rockwell, Dissertation, 1900). Finally, organic compounds were tried as precipitants for the separation of inorganic mixtures as, for example, "The action of salicylic acid upon the metallic acids" (J. H. Müller, Dissertation, 1910), and the use

of "Aromatic bases as precipitants for rare earth metals" (Alice McM. Jefferson, Dissertation, 1901).

II. INORGANIC, ANALYTICAL, AND ELECTROCHEMISTRY

It was to these fields that he devoted the major part of his fifty-two years of active research and an immense amount of valuable work was accomplished.

A. Electrochemistry

Perhaps his most important contributions were those he made to Electrochemistry, a domain in which he was a pioneer and soon became a recognized leader of international reputation. In the hands of this master craftsman, the electric current became a tool of undreamed-of usefulness and possibilities, opening up wholly new methods of analysis, separation and determination. About half of all the research papers he published were based upon new applications of the electric current. His introduction of the rotating anode together with the employment of currents of high amperage and high voltage, marked a new epoch in the development of electroanalysis. His books on electrochemistry quickly became and have since remained the standard texts in this country, while the Harrison Laboratory was soon known throughout the world for its leadership in this branch of chemistry.

B. Atomic Weights

The results obtained in the study of numerous inorganic compounds by the older methods and by these newly developed applications of the electric current, led to the discovery of new processes of analytical separation and to the preparation of many elements and compounds in exceptional purity.

This knowledge and these highly purified products were availed of by Dr. Smith and his co-workers in new determinations of the atomic weights of the elements, those fundamental units of our science. New ratios were established with the most

painstaking care and accuracy, for comparison with those already in the literature.

For example, Debray had shown, in 1852, that in a current of dry hydrogen chloride, molybdic acid could be completely volatilized as the dihydroxychloride. In the Harrison Laboratory this method was used to expel the molybdic acid from sodium molybdate, leaving only sodium chloride, and also as a means of separating molybdenum from tungsten. This suggested quite obviously a study of the behavior of other metallic oxides when treated similarly, with the consequence that many proved to be volatile not only in dry hydrogen chloride but also in other gaseous hydrogen halides. Such a complete elimination of certain of the elementary components of a pure compound provided another new way of arriving at atomic weight ratios.

In addition to this method and the electrolytic one of determining these atomic weight ratios, others were invented to meet the needs of special cases.

The elements included in these studies were Ag, Cd, Hg, Sc, V, Nb (Cb), Ta, N, As, Sb, Mo, W, Se, F, Cl, Br, B and Pd, a total of 18, or 20% of all now known to chemistry.

As the methods employed for these important determinations illustrate admirably the type of work then being conducted in the Harrison Laboratory, it will be instructive to consider them for a few moments in somewhat more detail, to appreciate fully the resourcefulness and skill of their directing genius.

(a) *Electrolytic Methods*

Silver is so beautifully and so completely precipitated by the electric current that varying amounts of silver nitrate were electrolyzed in the presence of potassium cyanide, and the precipitated silver weighed. Then silver acetate and silver benzoate were substituted in turn for the nitrate. The general average of these numerous determinations as carried out by Hardin (*J. Am. Chem. Soc.*, *18*, 990 [1896]) gave the atomic weight of silver as 107.928. The accepted figure today is 107.880.

Cadmium.—In 1892, Lorimer and Smith (*Z. angew. Chem.*,

1, 364), dissolved cadmium oxide in potassium cyanide, electrolyzed the solution, and weighed the metallic cadmium separated. The results indicated an atomic weight for cadmium of 112.055.

Four years later, Hardin and Smith (*J. Am. Chem. Soc.*, *18*, 990 [1896]) conducted similar experiments substituting anhydrous cadmium chloride and cadmium bromide for the oxide, and obtained a mean atomic weight of 112.045.

The average of all these determinations gave cadmium an atomic weight of 112.048. The figure now accepted is 112.41.

Mercury.—Hardin and Smith also electrolyzed mercuric chloride and bromide, in the presence of potassium cyanide, obtaining with the chloride an atomic weight for mercury of 200.006, and with the bromide of 199.883. The electrolysis of mercuric cyanide in platinum dishes gave an atomic weight of 200.071; while the simultaneous precipitation of mercury and silver from a cyanide solution by the same current, gave for mercury the value 199.996. The mean of all these determinations was 199.989. The accepted figure today is 200.61.

Palladium.—The determination of the atomic weight of palladium proved to be an exceptionally difficult task. Keller and Smith (*Am. Chem. J.*, *14*, 423 [1892]) electrolyzed an ammoniacal solution of palladammonium chloride, plating out the metal on the silver-coated platinum dishes which served as cathodes. The atomic weight of palladium found in this way was 106.914.

Seven years later (*Jour. Am. Chem. Soc.*, *21*, 943 [1899]), Hardin heated diphenyl-palladammonium chloride in a current of hydrogen, and obtained an atomic weight of 107.006 for palladium. Using the corresponding bromide, the figure was 107.036. In another series of experiments, he used ammonium palladium bromide instead, and found the value 107.00.

In 1908, Kemmerer (*J. Am. Chem. Soc.*, *30*, 1701 [1908]) heated palladammonium chloride, in an atmosphere of hydrogen and weighed the residual metallic palladium. The results won pointed to a mean atomic weight for palladium of 106.420.

Palladammonium cyanide, similarly treated, yielded the figure 106.458. He also undertook to precipitate silver and palladium by the same current, using as anodes pencils of these metals, planning in this way to compare the weights of the two metals separated upon the cathodes and thus to arrive at a direct ratio between palladium and silver. The failure of the experiments was traced to the presence of palladium still in the solutions.

Later, Shinn (*J. Am. Chem. Soc.*, *34*, 1448 [1912]) precipitated metallic palladium from an ammoniacal solution of palladammonium chloride by the addition of ammonium formate and by this method arrived at an atomic weight of 106.709 for palladium.

The atomic weight assigned now to palladium is 106.7. In the course of the reductions in a current of hydrogen, it was discovered that great care was necessary to avoid volatilization of palladium double salts and even of the metal itself; while Dr. Smith believes that the somewhat high results of the electrolytic method were not due to occlusion of hydrogen by the precipitated palladium, but to the presence of varying amounts of derivatives of quadrivalent palladium in the supposedly pure derivatives of the divalent palladium used for the experiments.

Chlorine and Bromine.—The quantitative determination of anions by the use of a mercury cathode and a rotating silver anode, was developed to such a high degree of accuracy that Goldbaum (*J. Am. Chem. Soc.*, *33*, 35 [1911]) decided to make use of it for determining the atomic weights of chlorine and bromine by electrolyzing the corresponding sodium halides and weighing the gain in weight of the silver anode. The results showed an atomic weight for chlorine of 35.459, and for bromine of 79.927; as over against the accepted figures of 35.458 and 79.916.

(b) *Methods Based upon the Volatilization of Certain Constituents in a Current of Dry Hydrogen Halide*

Molybdenum.—When normal anhydrous sodium molybdate was heated to about 300° in a current of dry hydrogen chloride,

the molybdenum oxide was removed completely, as MoO_3. 2HCl, leaving pure sodium chloride as the residue (Smith and Maas, *Z. anorg. Chem.*, *5*, 280 [1893]; *J. Franklin Inst.*, Sept., 1893). By comparing the weight of the residual sodium chloride with that of the initial sodium molybdate, an atomic weight for molybdenum of 96.08 was deduced.

A different method of attack was that of Müller (*J. Am. Chem. Soc.*, *37*, 2046 [1915]), who succeeded in oxidizing pure molybdenum metal quantitatively to MoO_3, and who thus arrived at an atomic weight of 96.03.

The average of these two sets of experiments is 96.055, in comparison with the official figure of 96.0.

Vanadium.—McAdam (*J. Am. Chem. Soc.*, *32*, 1603 [1910]), in the course of his work on the vanadates, exposed sodium metavanadate to the action of dry hydrochloric acid at high temperature, which removed the vanadium and left only pure sodium chloride. The atomic weight of vanadium calculated from these experiments was 50.967, while the figure which has been generally adopted is 50.96.

Antimony.—Friend and Smith (*J. Am. Chem. Soc.*, *23*, 502 [1901]), having discovered that antimony oxide could be removed completely from a mixture by virtue of its volatility in an atmosphere of dry hydrochloric acid, selected potassium antimonyl tartrate as a suitable salt for the establishment of a new ratio for antimony, and an atomic weight of 120.353 was derived thereby, as over against the present official figure of 121.77.

Nitrogen.—Hibbs (*J. Am. Chem. Soc.*, *18*, 1044 [1896]) ascertained that potassium nitrate could be converted quantitatively into potassium chloride by the action of dry hydrochloric acid at high temperature, and used this fact as the basis of a new way of learning the atomic weight of nitrogen. The value deduced was 14.0118. Another series of experiments with sodium nitrate in place of the potassium salt, gave 14.0116. The general average of these two sets, 14.0117, varies but slightly from the value generally adopted, 14.008.

Arsenic.—Hibbs (*Loc. cit.*) was also the discoverer of the fact that arsenic oxide could be removed completely from arsenates by the action of dry hydrochloric acid. Subjecting sodium pyroarsenate to this treatment, and weighing the sodium chloride formed, a mean value of 74.915 was found for the atomic weight of arsenic.

Ebaugh (*J. Am. Chem. Soc.*, *24*, 489 [1902]) conducted a similar series of experiments with silver arsenate and, from the weight of the residual silver chloride, calculated the atomic weight of the arsenic as 75.004. When the silver chloride was reduced to metallic silver, the weights of the latter obtained corresponded to an atomic weight of 74.975. He subjected lead arsenate to the action of dry hydrochloric acid, and also converted it into lead bromide, the first method giving an atomic weight of 75.022, the latter 75.00.

The general average of all these experiments led to the conclusion that the atomic weight of arsenic was not far from 74.983. The figure accepted now is 74.96.

Selenium.—Lenher (*J. Am. Chem. Soc.*, *20*, 555 [1898]) showed that silver selenite, exposed to dry hydrochloric acid at the proper temperature, lost its selenium completely and left pure silver chloride, from the weight of which the atomic weight of selenium could be calculated. The figure arrived at was 79.325. This figure was checked by reducing the silver chloride to metallic silver, and from the weight of silver obtained, the atomic weight of selenium was deduced as 79.329.

A third method used by Lenher was precipitation of selenium from an aqueous solution of its double ammonium bromide, $(NH_4)_2SeBr_6$, by the action of hydroxylamine. The atomic weight so obtained was 79.285, making the mean of all these three methods 79.313, in comparison with an accepted value of 79.2.

It is appropriate to recall here that Professor Lenher never lost the inspiration imparted to him by his great teacher or his interest in the chemistry of this particular element, a field in which he soon became a recognized world leader. It is believed

that his untimely death, a little over a year ago, was due either largely, or at least in part, to his continuous occupation with poisonous selenium compounds, and that his name should be added to that honor roll of those who have sacrificed their lives in the service of science.

Fluorine.—Sodium fluoride was subjected to the action of hot dry hydrochloric acid gas by McAdam and Smith (*J. Am. Chem. Soc.*, *34*, 592 [1912]), and from the weight of the residual sodium chloride, the atomic weight of fluorine was deduced as 19.015. The accepted value is 19.00.

(c) *Miscellaneous Methods*

Tantalum.—Chapin and Smith (*J. Am. Chem. Soc.*, *33*, 1497 [1911]), starting with tantalum pentabromide, hydrolyzed this by the addition of water, and evaporated the solution, adding small amounts of nitric acid towards the close of the evaporation, to eliminate all hydrogen bromide. The hydrated oxide so formed was ignited to Ta_2O_5 and the latter weighed. From the ratio of the weight of the Ta_2O_5 to that of the $TaBr_5$, the atomic weight of tantalum was calculated as 181.80 for the mean of all determinations. The official value is 181.5.

Columbium (*Niobium*).—Columbium pentachloride was hydrolyzed by Balke and Smith (*J. Am. Chem. Soc.*, *30*, 1637 [1908]) and the columbium oxide weighed. The mean atomic weight so found for columbium was 93.50.

Later, Smith and Van Haagen (*J. Am. Chem. Soc.*, *37*, 1783 [1915]) subjected sodium meta-columbate to the action of sulphur monochloride and were thus able to eliminate the columbic oxide quantitatively, leaving pure sodium chloride as the residue, from the weight of which residue the atomic weight of columbium was deduced as 93.13. The present accepted international value is 93.1.

Tungsten.—This metal and its derivatives have been the subjects of numerous important researches in the Harrison Laboratory. For the establishment of its atomic weight, eight different methods were used, namely: (1) reduction of the trioxide, (2)

oxidation of the metal, (3) weighing the water formed in the reduction of the trioxide, (4) extraction of the water content of barium meta-tungstate, (5) analysis of the hexachloride, (6) analysis of iron tungstate, (7) analysis of silver tungstate, and (8) determination of the water in sodium tungstate. From the figures obtained by these various processes, Dr. Smith was led to conclude that the correct atomic weight for tungsten was not far from 184.05, a figure very close to the present official value of 184.0.

Scandium.—The mean value of the atomic weight of scandium, as determined by Lukens (*J. Am. Chem. Soc.*, *36*, 819 [1914]), by calcination of the sulphate to the oxide, was 44.33. The international tables give the preference to the value 45.1.

Boron.—The determination simultaneously of the atomic weight of fluorine and of boron by Smith and Van Haagen (*Carnegie Inst. Pub.*, *267*, 1–63 [1918]) was based on the equivalent quantities of a number of different sodium salts formed by the conversion of anhydrous $Na_2B_4O_7$ through treatment with appropriate acids and repeated evaporation with methanol. From these data and the ratio $Na_2B_4O_7$:2NaF, the atomic weight of fluorine was calculated as 19.005. The borax used was prepared from pure Na_2CO_3 and H_3BO_3, the latter obtained by saponification of a carefully rectified methyl borate. Complete dehydration of borax proved difficult, but was finally accomplished by prolonged fusion. The methanol used was secured by hydrolysis of distilled methyl oxalate. The direct conversion of borax into sodium fluoride was found to be impracticable, and was attained through the formate. The atomic weight thus deduced for boron was 10.900, which is about 1% lower than the older value, and it is believed that the previous figure was inaccurate because of the retention of some water by the borax glass. The figure accepted today is 10.82.

C. Complex Inorganic Acids

Attracted by the brilliant pioneer work of Wolcott Gibbs, and in consequence of certain observations made in extracting large

quantities of tungstic acid from its ores, Dr. Smith determined to investigate certain complex inorganic acids and their derivatives. He succeeded in proving that many of those previously regarded as mixtures of isomorphs were actually distinct chemical individuals, and it was this study which caused him to announce that the great family of naturally occurring silicates was not made up of a series of salts of the several simple silicic acids, but really consisted of the alkali and alkaline earth salts of complex silicic acids, in which metallic oxides and silicic acid jointly formed the complex anion, a view which has been accepted quite generally by chemical mineralogists.

Many wholly new analytical separations and determinations were developed in the course of these studies, and a wealth of new chemical information gathered and carefully recorded.

The first of these studies was carried out by Smith and Exner (*J. Am. Chem. Soc.*, *24*, 573 [1902]) and concerned itself with ammonium vanadico-phospho-tungstate. This was followed up by Rogers (*J. Am. Chem. Soc.*, *25*, 298 [1903]), who prepared various ammonium salts of complex anions composed of the following oxides: $P_2O_5.V_2O_5.WO_3$, $P_2O_5.V_2O_3.WO_3$, $P_2O_3.V_2O_3.WO_3$, $As_2O_5.V_2O_5.WO_3$, $As_2O_5.V_2O_3.WO_3$, $As_2O_3.V_2O_3.WO_3$, $P_2O_5.V_2O_5.V_2O_3.WO_3$, $As_2O_5.V_2O_5.V_2O_3.WO_3$, $P_2O_5.As_2O_5.V_2O_3.WO_3$, and $P_2O_5.As_2O_5.V_2O_5.V_2O_3.WO_3$, with varying amounts of water. The complexity of such salts is obvious.

In later papers, Rogers and Smith (*J. Am. Chem. Soc.*, *25*, 1223, 1227 [1903]) prepared and described ammonium silicoso-, titanoso-, zirconoso-, thoroso-, and stannoso-vanadico-phospho-tungstates; and also ammonium vanadico- and vanadoso-tungstates.

Paralleling these studies, Balke and Smith (*J. Am. Chem. Soc.*, *25*, 1229 [1903]), by analogous methods, obtained ammonium and ammonium silver aluminico-tungstates, ammonium potassium and silicon bismuthico-tungstates.

Brubaker (Dissertation, University of Pennsylvania, 1904) added to this list the ammonium manganico-tungstate; ammonium and barium platinoso-tungstates, platinoso-phospho-

tungstates, platinoso-arseno-tungstates and platinoso-vanado-tungstates.

Daniels (*J. Amer. Chem. Soc.*, *30*, 1846 [1908]) investigated the aluminico-tungstates of copper, barium, mercury and zinc; the aluminico-phospho-tungstates of ammonium, silver, barium and zinc; the aluminico-arseno-tungstates of ammonium, barium and cadmium; the aluminico-antimonio-tungstates of ammonium, silver and barium.

Further contributions were made by Blum (*J. Am. Chem. Soc.*, *30*, 1858 [1908]) by the preparation and investigation of various phospho-vanado-molybdates.

This brief outline will suffice to give some idea of the labyrinthic character of this chemical jungle into which he penetrated so boldly and the difficulties of blazing clear trails therein.

In addition to the elements studied in connection with these complex inorganic acids and atomic weight determinations, he conducted investigations of numerous others, notable among these being such rarer ones as Be, Cs, Ge, In, Rb, Rh, Ru and Tl.

The field of analytical chemistry was enriched by many new methods of separation and determination, as well as by critical studies of methods already in vogue.

III. HISTORICAL CHEMISTRY

Great as have been Dr. Smith's contributions to electrochemistry and to the inorganic chemistry of the rarer elements, they are equalled or surpassed by the service he has rendered as historian of American chemistry, the field to which he devoted the riper years of his rich life.

Within the past two decades, no one has made so many or so important contributions to this field as he, or shown superior literary gifts in the presentation of his material; and in saying this I am not unappreciative of the admirable publications of Thomas Cooper, Venable, Moore, Stillman, and others. His facile pen and clever characterizations have made these chemists of previous years to live and breathe again, and their note-

worthy accomplishments, as well as their foibles and fancies, are described in such a natural and interesting manner that the narrative flows on smoothly and delightfully. Many of the chemists portrayed so charmingly and so vividly by him had been "overshadowed, neglected, forgotten."

Separate books, brochures or articles have been published by him concerning the following chemists:

Theodore G. Wormley, Jr. (1897), Robert Empie Rogers (1905), George F. Barker (1907), Fairman Rogers (1909), Robert Hare, an American Chemist (1917), James Woodhouse (1918), James Cutbush (1919), Franklin Bache (1922), James Curtis Booth (1922), Samuel Latham Mitchill (1922), Charles Baskerville (1923), Jacob Green (1923), Matthew Carey Lea (1923), Martin Hans Boyè (1924), John Griscom (1925), James Blythe Rogers (1927), Priestley in America (1920), Priestleyana (1922), and the Priestley Medal Lecture (1926).

More general treatises, written wholly or largely from the historical point of view were:

"Chemistry in America" (1914).
"Men of Science from the Keystone State" (1914).
"Chemistry in Old Philadelphia" (1918).
"The American Spirit in Chemistry" (1919).
"Progress of Chemistry" (1921).
"Our Science" (1922).
"A Half Century of Mineral Chemistry in America, 1876–1926" (1926).
"Observations on Teaching the History of Chemistry" (1926).
"Bromine and its Discoverers, 1826–1926" (1926).
"Early Science in Philadelphia" (1926).
"Fragments relating to the History of Chemistry in America" (1926).
"A Look Backward" (1927).
"A Glance at the Early Organic Chemistry of America" (1927).
"Old Chemistries" (1927).

The Commonwealth of Pennsylvania, and the Municipality of Philadelphia in particular, are especially in Dr. Smith's debt, for in these historical publications he selected preferably as the subjects of his study those whose activities had centered in this city or state. He has preserved in immortal classics those great figures in science whose life work has played so large a part in the progress of our country.

> "The riches of the commonwealth
> Are free, strong minds, and hearts of health;
> And more to her than gold or grain
> The cunning hand and cultured brain."

He was deeply concerned that the public should appreciate America's part in the advancement of chemistry, and that succeeding generations of chemists should be familiar with the pioneer work of their predecessors, for example that it was in America that the oxyhydrogen flame was discovered by Robert Hare in 1800, that potassium first was isolated here from its carbonate by heating the latter with lampblack, in 1808; that, in 1820, an electric furnace was constructed over here in which carbide, graphite and metallic calcium were produced; that the use of a mercury cathode in the electrolysis of metallic salt solutions originated with us, that we were the first to prepare chloroform by the interaction of alcohol and hypochlorite; and that the Chemical Society of Philadelphia, founded in 1792, was the first organization of its kind in the world.

It is a source of the deepest satisfaction and the sincerest congratulations that Mrs. Smith has presented to the University of Pennsylvania the splendid collection of historical books, documents, letters, photographs, and other memorabilia collected by her husband, and that they are to remain permanently, as a Museum of Chemical History, in that office where so much of his life was spent.

The University of Pennsylvania has come into possession of what is undoubtedly the finest collection of its kind in this hemisphere and one of the best in the world.

It is peculiarly fitting that his office, so familiar to all his

friends and where he had gathered about him those things which brought him the greatest pleasure, thus becomes a shrine to which frequent pilgrimages will be made by all American chemists who cherish the memory of those who have been the chief builders of their science, as well as by the many who knew and loved the quiet, unassuming, generous comrade who was its ornament and its chief attraction.

Somewhere in that Museum there should be displayed prominently the classic lines of Philip James Bailey, which seem to me to sum up so accurately and so beautifully the principles which guided the life of Edgar Fahs Smith:

> We live in deeds, not years; in thoughts, not breaths;
> In feelings, not in figures on a dial.
> We should count time by heart-throbs. He most lives
> Who thinks most—feels the noblest—acts the best.
> Life's but a means unto an end—that end,
> Beginning, mean, and end to all things—God.

Instead of placing a wreath upon my friend's tomb, I am bringing as my tribute something which I am sure will please his spirit far more, and I hand to you, therefore, Mr. Provost, this ancient official order, dated Paris, December 24, 1791, for the payment of salaries and other expenses of officers of the Gendarmerie Nationale, signed by the great Lavoisier himself, the father of modern chemistry, as Commissaire of the National Treasury. It was secured by me in Paris a few years ago, and I know of no more worthy resting place for it than in the Smith Museum of Chemical History.

ADDRESS

By PROVOST PENNIMAN

Dr. Penniman read letters and telegrams received from the following:

JOHN S. FISHER, LL.D.
Governor of Pennsylvania

JOHN H. FINLEY, LL.D., L.H.D., J.U.D.
Editor of the "New York Times"

E. R. WEIDLEIN, Sc.D.
President of the American Institute of Chemical Engineers, Director of the Mellon Institute

DR. CESARE SERONO
Professor of Chemistry and Chemical Microscopy, University of Rome

FRITZ HABER, PH.D., M.D.
Director of the Kaiser Wilhelm Institute of Physical Chemistry, Berlin

DR. H. WIELAND
Professor of Chemistry, Bavarian Academy of Sciences, Munich

DR. N. ACH
Dean of the Faculty, University of Göttingen

DR. ERICH MÜLLER
Editor of the Zeitschrift für Elektrochemie und Angewandte Physikalische Chemie

SIR JAMES COLQUHOUN IRVINE, PH.D., D.Sc., LL.D.
Principal and Vice-Chancellor, University of St. Andrews

ALFRED TINGLE, PH.D.
Chief of the Customs-Excise, Ottawa

THE INSTITUTION OF CHEMICAL ENGINEERS, London

J. F. THORPE, PH.D., D.Sc.
Professor of Organic Chemistry, Imperial College of Science of Technology, London

PRINCE GINORI CONTI, Sc.D.
Senator of the Kingdom of Italy, President of the Italian Chemical Society

EDWARD HART, PH.D., LL.D.
Professor Emeritus of Chemistry, Lafayette College

THERE have been literally hundreds of letters of this kind from men of distinction—chemists, professional associates of Dr. Smith, and friends of that "friend of the wise and teacher of the good." So much has been said in these admirable addresses this afternoon that it would be a work of supereroga-

tion were I to attempt to add to what you already know or to repeat what has already been said. But I do wish to add just a word of tribute more directly from our own University, and a statement by one who was for forty years a close associate and friend of the late Provost.

He had clearness of vision and profound sympathy with men in doubt and difficulty—a sympathy the expression of which was known to no one but those to whom he expressed it. Many of us know the brightness he brought into the lives of thousands, and the letters that came to us when the announcement was made that he had passed beyond, bear witness to this fact. It was true that he was a great light-bearer. The brilliance of the incandescent electric lamps in this hall is due to the tungsten filament made possible by a process discovered by Dr. Smith and Dr. Exner in the Harrison Laboratory of Chemistry just across the street. Are not these lights symbolic of the life of Dr. Smith in its influence on others?

His deep sympathy—the illumination he threw on the dark spots of life—and no one else knew how dark they could be—was something almost beyond our comprehension. With all there was a child like religious faith that characterized this great scientist. One of his lifelong friends brought me a letter written by Dr. Smith thanking him for the Bible that he had presented, and saying, "I use it daily." And those of us who knew him know how true these words were, how greatly and how deeply the teaching of Christ actuated and influenced the life of this man. He had a broad conception of the purposes and the opportunities of life, and an unwillingness to let any opportunity, however unlovely, slip past his grasp, if by the laying on of the hand, or the speaking of the word of kindness, he could lighten the burden of some fellow being.

Many are the University boys, and many the men, not of the University, whose lives were touched by this great man, who seemed almost to have in his tongue and hand the power of healing the wounded and suffering souls. I know that. I know it personally, and I know it by what others have told me. With

it there was an indefatigable energy—the determination to work incessantly, which the speakers have referred to—to work far into the hours of night—to work all night.

He never complained that he could not do original work because he had a heavy roster. He never complained that he could not do original work because he had no time. He took the time and did the work. During the entire period of his provostship of this University he did what no other man did who has had like responsibilities placed on his shoulders—he did not diminish by an hour his teaching roster. Think of that!

These are a few of the qualities, ladies and gentlemen, friends of Edgar Smith, that explain Edgar Smith so far as it is possible to explain any man to any other man. Man is a great mystery to himself and he is a great mystery to his friends. The greatest detective story ever written would be a detective story about a man who tried to trail himself—who tried to discover himself.

Indeed that Greek maxim, "Know thyself," was spoken with a profundity of wisdom which even the Greek philosopher who wrote it may not have appreciated wholly.

I have often read the lines Matthew Arnold wrote of his father in the poem "Rugby Chapel." In some respects they apply to the life and influence of Edgar Smith. I will read a part of that poem to you, and ask, as we hear Arnold set forth the work of that great master mind that affected England, that entered into the spirit of fair play that the English speak of when they say a thing is "not cricket"—the kind of spirit put into those boys by Arnold—whether another man did not do a similar work in moulding character, and putting into the souls of American youth the spiritual ideals which made it impossible for any man who ever came under the influence of Edgar Smith, to deceive himself in regard to what was right and what was wrong. Every such man knew what was right because he had been in contact with a great life and been under the influence of a great teacher.

What is the course of the life
Of mortal men on the earth?
Most men eddy about
Here and there, eat and drink,
Chatter and love and hate,
Gather and squander, are raised
Aloft, are hurled in the dust,
Striving blindly, achieving
Nothing; and then they die,—
Perish; and no one asks
Who or what they have been
More than he asks what waves
In the moonlit solitudes mild
Of the midmost ocean, have swelled,
Foamed for a moment, and gone.

And there are some whom a thirst
Ardent, unquenchable, fires,
Not with the crowd to be spent,
Not without aim to go round
In an eddy of purposeless dust,
Effort unmeaning and vain.
Ah yes! some of us strive
Not without action to die
Fruitless, but something to snatch
From dull oblivion, nor all
Glut the devouring grave,
We, we have chosen our path,—
Path to a clear-purposed goal,
Path of advance; but it leads
A long, steep journey, through sunk
Gorges, o'er mountains in snow.

Cheerful, with friends, we set forth:
Then, on the height, comes the storm.
Thunder crashes from rock
To rock; the cataracts reply;
Lightnings dazzle our eyes;
Roaring torrents have breached
The track; the stream-bed descends
In the place where the wayfarer once
Planted his footstep; the spray
Boils o'er its borders; aloft,
The unseen snow-beds dislodge
Their hanging ruin. Alas!
Havoc is made in our train!
Friends who set forth at our side
Falter, are lost in the storm.
We, we only are left!

With frowning foreheads, with lips
Sternly compressed, we strain on,
On; and at nightfall at last
Come to the end of our way,
To the lonely inn 'mid the rocks;
Where the gaunt and taciturn host
Stands on the threshold, the wind
Shaking his thin white hairs,
Holds his lantern to scan
Our storm-beat figures, and asks,—
Whom in our party we bring?
Whom we have left in the snow?
Sadly we answer, We bring
Only ourselves! we lost
Sight of the rest in the storm.
Hardly ourselves we fought through,
Stripped, without friends, as we are.
Friends, companions, and train,
The avalanche swept from our side.

But thou wouldst not alone
Be saved, my father! alone
Conquer and come to thy goal,
Leaving the rest in the wild.
We were weary, and we
Fearful, and we in our march
Fain to drop down and to die.
Still thou turnedst, and still
Beckonedst the trembler, and still
Gavest the weary thy hand.

If, in the paths of the world,
Stones might have wounded thy feet,
Toil or dejection have tried
Thy spirit, of that we saw
Nothing; to us thou wast still
Cheerful, and helpful, and firm!
Therefore to thee it was given
Many to save with thyself;
And, at the end of thy day,
O faithful shepherd! to come,
Bringing thy sheep in thy hand.

And through thee I believe
In the noble and great who are gone;
Pure souls honored and blest
By former ages . . .

BENEDICTION

THE REVEREND RICHARD MONTGOMERY

The grace of our Lord and Saviour Jesus Christ and the love of God and the fellowship and communion of the Holy Spirit be and abide with you all evermore. Amen.

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ACJ —American Chemical Journal.
AJS —American Journal of Science.
APSP —American Philosophical Society Proceedings.
ASS —Archivio di Storia della Scienza (Italy).
BdcG —Bericht der deutschen chemischen Gesellschaft (Germany).
CN —Chemical News.
JFI —Journal of the Franklin Institute.
JACS —Journal of the American Chemical Society.
JAAC —Journal of Analytical and Applied Chemistry.
JCE —Journal of Chemical Education.
JIEC —Journal of Industrial and Engineering Chemistry.
NASM—National Academy of Science Memoirs.
PM —The Pennsylvania Magazine of History and Biography.
PANS —Proceedings of the Academy of Natural Sciences, Philadelphia.
S —Science.
TAES —Transactions of the American Electrochemical Society.
ZaC —Zeitschrift für anorganische Chemie (Germany).

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